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Introduction

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High land values and increases in all other farming costs make it imperative that apples be produced economically and an early return on the investment be realized. The use of appropriate apple rootstocks has greatly improved the economics of growing apples.

Apple trees are not grown on their own roots but propagated on rootstocks that control the tree. Dwarfing rootstocks control wood production in the tree, directing its energy into fruit production. By choosing the rootstocks for your needs and soil conditions, you can preselect, to a considerable extent, the size of your orchard trees at maturity. This choice, in itself, can save a great deal of labour in pruning and picking, and time waiting for your trees to start cropping.

Dwarf trees grow apples where most, if not all, of the fruit can be picked without ladders. To improve efficiency in the picking operation and to increase yield per hectare, dwarf to semi-dwarf trees are planted at close intervals in the rows. This type of high-density planting provides a continuous tree wall of bearing surface to be sprayed and picked, thus reducing waste of time and materials.

High-density relates to maximum light interception by the leaves of the trees rather than specifically to the number of trees per hectare. For maximum light interception to occur, a minimum amount of sunlight is lost on the ground between trees. It has been shown that fruit size and total fruit production increases when light interception and utilization are increased. In general, the more dwarfing the rootstocks, the better they lend themselves to high-density planting, with early economic return.

Most of the rootstocks available for apples were not bred or selected for winter hardiness in Canada. Consequently, the roots or stems suffer cold injury occasionally in certain locations across Ontario. Avoid excessive cultivation or feeding that induces late, immature growth. Sod cover with mulch under the trees provides protection for the roots against extremes of temperature.

Depending on which rootstock is used, apple trees may be broadly classified into 4 categories: dwarf, semi-dwarf, semi-vigorous or semi-standard, and vigorous or standard size. These are relative terms. Tree size at any age will vary with the cultivar, the soil, nutrition, pruning practices, amount of cropping, and climate.

The number of rootstocks available commercially for dwarfing apple trees is steadily increasing. Not all of these rootstocks are suitable for apple production in Ontario. Before selecting a rootstock be sure to research the options available. There are varying opinions on the performance of the different rootstock depending on the environment under which they have been evaluated. The rootstocks listed in this factsheet are the ones believed to have the most promise for Ontario growing conditions.

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Dwarf

These rootstocks have the added advantage of being very precocious, with high yield efficiency. This allows growers to change cultivars as necessary without extended periods of lost production. The traditional concept that an orchard is a lifetime venture must be abandoned considering the economic pressures of today.

Since the fruiting canopy is so close to the ground with dwarf rootstocks, do not plant on sites where accumulation of cold air causes frequent frost conditions during the spring. Under such circumstances, loss of a crop can lead to excessive regrowth and crowding, which may prove difficult to control. Where heavy snow accumulations occur, limbs of trees on dwarf rootstocks may be damaged or pulled from the trunk as the snow melts or settles.

Dwarfing rootstocks have a limited root volume and benefit from supplemental irrigation in dry seasons and in droughty soils. Dwarfing rootstocks also benefit from total tree support for the life of the orchard.

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M.27 (Malling 27)

An extremely dwarfing rootstock released in 1971 from the East Malling breeding program, England. M.27 is probably too dwarfing to be useful in commercial orchards. It makes a tree about 20% the size of standard and half the size of on M.9 or smaller. As it is a slow, weak grower in the stoolbed, special techniques are needed to produce plants in quantities for commercial use. Winter hardiness is the same as M.9, and it does not produce root suckers or burr-knots. It is very precocious and is less susceptible to fire blight than M.9.

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V.3 (Vineland 3)

This is a new dwarfing rootstock originating from the Vineland breeding program, Ontario. This rootstock is slightly less vigorous than M.9 EMLA but similar to the M.9 clones M.9 T337 and M.9 Flueren 56. Trees on V.3 have a similar propensity to form root suckers and appear to be as productive as the M.9 clones, but are more yield-efficient. Preliminary tests indicate it is moderately resistant to fire blight. This stock is presently being evaluated for winter hardiness, disease and insect resistance, incidence of burr-knots and root suckers, and susceptibility to collar-rot. The rootstock will be commercially available as early as 2001.

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G.65 (Geneva 65)

This is a patented rootstock from the Cornell University breeding program, New York State. It is a very dwarfing stock producing a tree smaller than M.9. It is precocious and productive. It is resistant to fire blight and collar-rot and is moderately susceptible to woolly apple aphid. It has few burr-knots and few suckers.

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M.9 (Malling 9)

Released from the East Malling research station, England, this rootstock is the most dwarfing in commercial use in Ontario today. It produces a tree size approximately 25%-30% of full size with most cultivars. Many subclones of M.9 exist today, the result of heat treatment to rid the original clones of viruses and selection for ease of stoolbed propagation. Clones vary somewhat in the degree of dwarfing imparted to the scion. The original M.9 clone containing viruses produces a tree about 30% smaller than the virus-negative M.9 EMLA. The French Pajam 2 (Cepiland) is a relatively vigorous clone, Pajam 1 (Lancep) and the Dutch NAKB T337 are intermediate and Fleuren 56 is less vigorous.

Dwarf trees on M.9 are not necessarily short-lived or shallow-rooted. Root development is proportional to tree height and spread. M.9 is not drought-tolerant. Do not grow trees on this stock on light-textured soils without supplemental irrigation. The wood of the M.9 stock is brittle and will break suddenly under stress. Trees on M.9, therefore, need to be supported throughout their lifetime. M.9 will not do well under poor drainage but it is tolerant of collar-rot and does well on heavier soils where drainage is adequate.

M.9 is prone to some suckering; since it is extremely susceptible to fire blight. Take care to discourage any suckering that may occur. The rootstock is also susceptible to woolly apple aphids. M.9 readily forms burr-knots, groups of root initials which form on the rootstock. These burr-knots are entry points for borers and other pests.

M.9 is reported to be moderate to good in hardiness. It stops growth of the scion relatively early permitting increased early hardening of the scion. Caution should be exercised if this rootstock is planted in the colder growing districts of Ontario or on sites which frequently lack snow cover.

M.9 is very precocious, and uncontrolled flowering can lead to runting-out of the tree especially on light-textured soils. Where conditions favour vigorous tree growth, early fruiting may be essential to control tree size. The well-exposed limbs and limited structural wood of a tree on M.9 favour the production of large size and excellent coloured fruit. Trees on M.9 are very productive.

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Mark

Originated as MAC-9 (Michigan Apple Clone) from Michigan State University, this patented rootstock was released for commercial use in 1985. Tree size is slightly less than M.26 and it can grow freestanding. It has a tendency to crop heavily on young trees and may cause stunting if fruit are not adequately thinned. Mark is resistant to collar-rot but susceptible to fire blight and woolly apple aphid. Burr-knots are formed about the same as on M.26. but it does not sucker. It is very precocious. A conspicuous tumor-like swelling surrounds the Mark rootstock at the soil line. The cause of soil-line swelling is unknown.

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V.1 (Vineland 1)

Originated from the Vineland breeding program, Ontario. Tree size is comparable or slightly larger then M.26. Yield efficiency and fruit size are equal to or greater than M.26. Propensity to sucker is equal to M.26. Unlike M.26, V.1 appears to be highly resistance ot fire blight. The rootstock will become commercially available as early as 2001.

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Bud 9 (Budagovsky 9)

Is a dwarfing rootstock bred in the Soviet Union. Its leaves are red. Tree size falls between M.26 and M.9 EMLA in vigour. It is a precocious rootstock with high yield efficiency. It requires support. Bud.9 is resistant to collar-rot and susceptible to fire blight and woolly apple aphid. Bud.9 has excellent winter hardiness much greater than M.9. It produces few suckers or burr-knots. It is a promising dwarfing winter-hardy rootstock.

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O.3 (Ottawa 3)

This is the most dwarfing rootstock to come out of the cold-hardy breeding program at Ottawa. It appears more dwarfing than M.26 but more vigorous than M.9. Ottawa 3 roots sparsely in the stoolbed but can be grown from root cuttings or tissue culture. It is more cold-hardy than M.26 or M.9 and is resistant to collar-rot but susceptible to fire blight and woolly apple aphid. It does not produce burr-knots or root suckers. It is precocious and requires support while young. Its management requirements are similar to those for M.26. The orchard performance has not been determined.

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M.26 (Malling 26)

A dwarfing rootstock introduced from East Malling in 1959. This rootstock has been quite popular in the last 10 years. M. 26 is recommended in all apple districts of Ontario, but on a trial basis only in colder districts. M.26 is reported to be the most hardy of the Malling series rootstocks.

The tree is about 40% of standard size, being larger and sturdier than M.9 but smaller than MM.106. Although its roots are not brittle, anchorage of M.26 is only fair. These trees need to be supported during the canopy-development phase of growth to prevent leaning. Under normal conditions, M.26

will become self-supporting after about 5 to 8 years but tree support is still recommended for early economical cropping. M.26 is strongly influenced by soil conditions. Not drought-tolerant, M.26 easily runts out on very sandy soils without supplemental irrigation. It will do well on intermediate or heavier-textured soils if drainage is adequate. While moderately resistant to collar-rot, M.26 will not perform satisfactorily on poorly-drained sites.

Trees on M.26 are very precocious, and control of early fruiting is critical to success with this rootstock. Uncontrolled early fruiting slows development of good anchorage, induces loss of vigour, produces fruiting-out and loss of the central leader and encourages the onset of a spur-bound condition. The trees respond to intensive training and pruning similar to trees on M.9.

M.26 readily forms burr-knots. Deep planting, keeping the union just above the soil surface, reduces burr-knot formation, increasing tree stability and discourages suckering.

M.26 has good resistance to collar-rot. M.26 is apparently susceptible to fire blight. As a precaution against infection, remove rootstock suckers promptly.

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G.30 (Geneva 3)

A patented rootstock released in 1994 from the Cornell University breeding program, New York State. This is a Robusta 5 X M.9 cross 60%-65% the vigour of seedling, similar to M.26. This rootstock appears to be more productive than M.7 but similar to M.26 It is bred for its resistance to fire blight. Is prone to some suckering. One notable problem with G.30 is that it forms a weak graft union with brittle cultivars such as 'Gala'. For this reason such rootstock:scion combinations are not recommended and tree support is advised for all cultivars.

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V.7 (Vineland 7)

From the Vineland breeding program. Tree size is similar to M.7. This rootstock is undergoing further testing at the University of Guelph, Simcoe Research Station, and at the time of print no schedule for commercial release is available.

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V.2 (Vineland 2)

From the Vineland breeding program. Tree size is 20% larger than M.26 based on trunk cross-sectional area and tends to be wider while similar in height to M.26. Productivity is equal to or slightly greater than M.26. Premilinary fire blight testing of V.2 indicate it is moderate-highly resistant - comparable with M.7. Tree survival of V.2 is comparable or better than M.26, especially in colder climates. The rootstock will become commercially available as early as 2001.

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Dwarfing Interstocks

Dwarf trees can be obtained by using dwarfing interstocks on vigorous rootstocks. Productivity is usually proportional to tree size. Staking is advised where M.9 or other brittle interstock is used.

General planting of interstock trees is not recommended in Ontario because of additional costs, the inherent suckering, and the confusion that can occur with depth of planting and the multiple number of possible stock, interstock and scion combinations. In unusual situations such as in coldest districts, 0.3 on Robusta 5 may be tried. Growers wishing to plant interstem trees should order from a nurseryman 1 or 2 years in advance.

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Semi-Dwarf Trees

Many trees were planted on semi-dwarfing rootstocks in the '50's and '60's, popularity resting with Malling 7 at first, but later swinging to MM.106. Both are now in much less demand than M.26 or M.9.

The planting of the so-called semi-dwarf apple tree has been a compromise between the big standard apple tree that requires much ladder work and the small dwarf tree that can be pruned and picked from the ground. By the time the semi-dwarf tree attains sufficient size to crop satisfactorily, some ladder work is required to pick and prune. As semi-dwarf trees have a limited bearing area, the orchardist is advised to plant more than 250 trees per hectare for economic production.

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M.7 (Malling 7)

Released from the East Malling breeding program, this rootstock gives a tree a little larger than M.26 and a little smaller than MM.106. It is generally too vigorous for high density plantings. It is available in various virus reduces states such as M.7A, M.7 EMLA. It performs best on a good soil in a location protected from the wind, in a district with relatively mild winter temperatures. Bud high and plant deeply to improve anchorage and to reduce the strong tendency to produce root suckers. M.7 is a good producer of plants in the stoolbed, but in comparative orchard trials, fruit production on M.7 has not been impressive.

As a rootstock in the orchard, M.7 has a history of poor anchorage, low uptake of potassium and frost-tender roots. Fruit production is relatively light for the first 10 years, after which ladders are needed to pick the fruit. Except where previous experience has been favourable, growers are cautioned against making extensive plantings on M.7.

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V.4 (Vineland 4)

From the Vineland breeding program. Produces a tree similar in size to M.7. This rootstock is undergoing further testing at the University of Guelph, Simcoe Research Station, and at the time of print no schedule for commercial release is available.

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MM.106 (Malling-Merton 106)

Released from the combined efforts of the East Malling and the Merton research stations breeding program. This rootstock makes a well-anchored tree whose size ranges from a large semi-dwarf to three-quarters of standard size or larger, depending on soil and cultivar. In comparative 12-year trials at Vineland and Simcoe, trees of McIntosh, Delicious and Northern Spy on MM. 106 have demonstrated outstanding productivity. Like M.7. MM.106 has some susceptibility to collar-rot, so that neither should be planted in old orchard sites where losses from collar-rot have occurred. MM.106 is sensitive to moisture. Abundant rainfall late in the season sometimes delays maturity of the trees predisposing them to low temperature injury. Imperfect soil drainage can also result in loss of trees.

Where there is no objection to tree size, MM.106 is recommended for general planting on well-drained soils in Ontario, but only on a trial basis east of Hastings County. MM.106 is a good propagator in the stoolbed, rooting well and producing a stock of budding size the first year in the nursery. Though bred for woolly aphid resistance, it is not immune.

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Semi-Vigourous and Vigourous Trees

There appears to be little future for trees three-quarters of standard size or larger. They are slow to start cropping and costly to prune and pick.

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MM.111 (Malling-Merton 111)

This tree is about the best in this class, although tree size is about 80% of standard. Though slightly more vigorous than the old M.2, the anchorage of MM. 111 is better and the tree seems adaptable to a wider range of soil conditions. Commercial stocks of MM.111 are virus-free and appear resistant to collar-rot.

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Robusta 5

This is no longer recommended as a root or body stock in Ontario. It has a very short rest period and may break dormancy during a mild spell in winter. A subsequent freeze can result in sunscald, bark-split, cambium injury and even death of the tree. Where no frost injury occurs, the trees are difficult to manage, being more vigorous than standards. Robusta 5 was developed at Ottawa and should be considered as a rootstock only in the coldest districts where the winter is not broken by mild spells.

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Other Rootstocks

There are more rootstocks entering the picture every year. These stocks are still considered to be experimental and are only being planted on a very limited basis for evaluation. Among these stocks are the MAC series (Michigan Apple Clone), the Budagovsky series from Russia, (Bud) the Polish series (P) plus others.

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Virus-Tested Rootstocks

The old Malling stocks carried virus diseases. Released about 1960, M.9A, M.7A and M.2A are free of chat fruit, rubbery wood and apple mosaic but still carry the latents such as stem pitting, chlorotic leaf spot and spy epinasty.

In 1973, East Malling and Long Ashton released the EMLA clones of M.9, M.26, MM.106 and MM.111 that are free of the latent viruses as well as the other viruses. The elimination of virus content has resulted in greater vigour for each rootstock selection relative to its virus-infected parent. Preliminary reports indicate that virus-tested rootstock selections produce trees at least 10%-15% larger than comparable trees on infected rootstock material. The Malling-Merton clones were never seriously infected but the EMLA clones of them are completely free of known viruses.

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Depth of Planting

The proper depth at which to plant apple trees remains a very important issue. With the exception of high density supported systems (slender spindle, vertical axis, etc.), the bud union should be positioned 5 cm above the final soil level. The length of rootstock shank above the soil surface

determines the vigour of the scion. This is a greater factor with dwarf than more vigorous rootstocks. To plant deeper may lead to the scion growing roots and the dwarfing influence of the rootstock being lost. To have the union excessively above the ground will reduce the size of the tree and introduces the possibility of burr-knots or aerial roots developing. This disruption in the bark can be invaded by the dogwood borer and lead to tree losses. For consistency of tree size and to reduce unnecessary trunk injury, special care is required to properly position the bud union.

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Orchard Planting Densities

Orchard planting plans may be grouped into three general classes according to tree population (density) per hectare (Tables 1 and 2).

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Low Tree Density

The spacing at planting time provides for full development of the tree, except for a minimum of training and corrective pruning. This plan requires the least investment per hectare in trees. Land must be cheap. While wide tree spacing has been an accepted feature of the conventional orchard in the past, it is not recommended for orchards planted now. The projected life of an orchard planted at low density is possibly 40 years.

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Medium Tree Density

The moderately close spacing of this plan requires a relatively high investment in trees, and in labour to manage them, which should be more than offset by increased returns. The trees are trained to a central leader. They are held to their allotted space by peripheral (surface) pruning, reducing the natural spread by at least 20%. The medium density is only recommended in special cases where environmental concerns are major considerations such as spring frosts and wind. Projected orchard lifetime about 20 years.

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High Tree Density

The higher the tree population, the greater the need to program the management system for the life of the orchard. Many variations in plan are possible. Dwarfing stocks must always be used. The possible advantage of earlier returns is offset against greater cost per hectare for trees.

Methods of training and pruning must be very specialized to control tree size and induce early cropping. Freestanding trees should never be used for these systems. Higher density supported systems such as slender spindle and vertical axis have shown great advantages over freestanding high density plantings.

There is also the possible need for irrigation, and the risk of fruit colour and size declining as trees reach greater size at maturity. Fruit colour and size decline as exposure to light decreases. Quality is as important a factor in profits as is quantity.

A guide to tree spacings for each of the different orchard densities is given in Table 2. The suggested spacings in the table are for soils of average fertility and cultivars of average vigour.

Table 1.Suggested Spacing in metres (m) of apple cultivars of average vigour on certain leading rootstocks

Rootstock	Low Density	Medium Density	High Density
M.9	----	2.5 x 5.0	1.5 x 3.5
M.26	4.0 x 6.0	3.0 x 5.5	2.5 x 4.5
M.7	5.5 x 8.0	4.5 x 6.5	3 x 4.5
MM.106	6.0 x 8.5	5.0 x 7.5	3.5 x 6.0
MM.111	6.5 x 9.0	5.5 x 8.0	----
Vigourous Rootstocks	7.5 x 10.0	6.0 x 8.5	----

Table 2. Number of trees per hectare at various spacings [2]

Distance between trees (m)	Distance between rows (m)																	
	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	
1.5	3333	2667	2222	1905	1667													
2	2500	2000	1667	1428	1250	1111	1000	909										
2.5		1600	1333	1143	1000	889	800	727	667									
3			1111	952	833	741	667	606	555	513								
3.5				816	714	635	571	519	476	440	408							
4					625	555	500	455	417	385	357	333						
4.5						494	444	404	370	342	317	296	278					
5							400	364	333	308	286	267	250	235				
5.5								330	303	279	260	242	227	214	202			
6									278	256	238	222	208	196	185	175		
6.5										236	220	205	192	181	171	162	154	
7											204	190	178	168	159	150	143	

[2]To find number of trees / ha at any other metric planting distances, multiply distance between trees (m) by distance between rows (m) and divide 10,000 by that product.

Sources: John Cline, Department of Plant Agriculture, University of Guelph, Simcoe, Ontario
Bruce H. Barritt, Intensive Orchard Management, Good Fruit Grower, Yakima, WA

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